Navigation

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TMO Technology Program Quarterly Review

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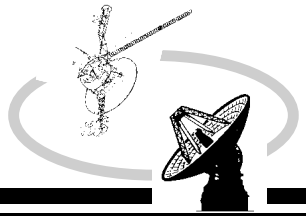
Navigation
Objective and Significance

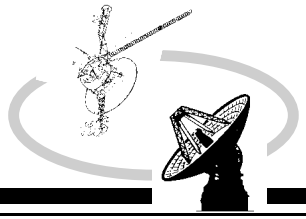


Overall Objective

The Navigation work area long-term objectives are to (1) increase the efficiency, reliability, and accuracy of the DSN-based navigation process, (2) reduce the overall cost and effort of navigation operations, and (3) shape the evolution of the DSN's navigation capabilities to meet the needs of future customers.

Goals	Significance
• Develop new techniques to improve navigation performance without increasing costs	• Monitor and characterize anomalous spacecraft behavior in near real-time • Ensure efficient use of DSN tracking for additional missions ¤ Discovery/SMEX class missions ¤ Small body missions ¤ Unstable orbit missions
• Develop new low-cost methods to streamline DSN navigation operations	• Decrease operations costs for modeling spacecraft • Minimize redundancy in software efforts for mission planning and navigation
• Develop new navigation software systems to support future automated ground-based and on-board navigation efforts	• Consolidate efforts to create and maintain separate software systems for off-line, autonomous ground-based, and on-board navigation • Enable analysts to provide quick, near real-time navigation support in critical scenarios

Navigation
Products and Customers



Product	User/Customer	Development Phase: Concept	Design	Demo	Transfer	Approach/Comments
"Stepping Stone" Approach to the Next Generation Navigation Software System	All missions	■	■			Builds on 'lessons learned' from successful ARTSN prototype
RAMPS (Real-time Automated Measurement Processing System)	All missions, DSN			■		Automated real-time data conditioning software
Automated Maneuver Optimization	Future missions, DSN	■				Intended to increase functionality of an automated spacecraft navigation system
Navigation Tracking Strategies and DSN Operations Requirements for Discovery and SMEX Class Missions	Future missions, especially Discovery and SMEX Class	■				Evaluate data types and strategies to minimize costs of tracking and TMOD operations
Adaptive Interplanetary Navigation	All missions, DSN		■			Performed jointly with the University of Texas/Center for Space Research
On-Board and Ground-Based Navigation Tradeoffs for Close-Proximity Operations and Landing on Small Bodies	Future small body missions, DSN	■	■			Identify interplay between ground and autonomous navigation for operations; work performed with Iowa State University
Navigation in Unstable Orbits and on Unstable Manifolds	Future missions, DSN	■	■			Work performed with Iowa State University

Navigation
The "Big" Picture

The Navigation work area/unit generally fits into these elements of the overall TMOD environment.

Fill Codes:
- Flight
- Ground
- Flight & Ground

Check all that apply:
- ✔ Automation
- ✔ Autonomy
- GSE
- ✔ Development
- ✔ Operations
- ✔ Flight
- ✔ Ground
- H/W
- ✔ S/W
- Protocol
- Testbed

Avionics

Instrument

Telecom & Relay

Schedule

Nav & Trk

Plan & Seq

Miss Des

Analyze

Rcvr

Cmnd

Ant / Optics

Networks

Eng Proc

Visualize

Xmtr

Telemetry

Data Mgmt

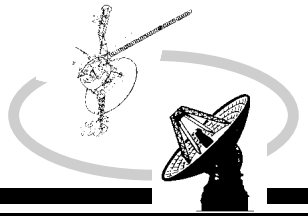
Sci Proc

Data Prod

Other Infra

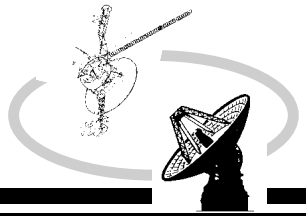
Mon & Cntrl

Navigation
Relevant Technical Skills



- **Technical Strengths**
  - **Orbit Determination**
  - **Maneuver Design**
  - **Trajectory Design**
  - **Small Body Dynamics and Modeling**
  - **Adaptive Filtering**
  - **Navigation Planning & Support**
  - **Real-Time Software Design**
  - **Navigation System Design**
- **Other Capabilities**
  - **Navigation Data Assessment**
- **Skills Needed**
  - **Object-Oriented Software Designers with ‘Large Software Effort’ Success**

Navigation
FY98 Q1 Accomplishments



T. Drain

- **'Stepping Stone' Approach to the Next Generation Navigation Software System**
  - **Delayed work due to unavailability of funds**
  - **Discussed ideas for overall goals and plan - to be presented at February retreat**

D. Burkhart, T. Drain

- **Completed initial end-to-end demonstration of ARTSN pre-processor RAMPS (Real-time Automated Measurement Processing System)**
  - **Performs real-time validation of radio metric data, with real-time residual display**
  - **Necessary for reliable real-time orbit determination**
  - **Compatible with current navigation software**

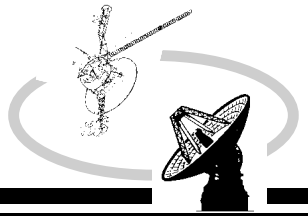
C. Potts

- **Automated Maneuver Optimization**
  - **Investigated candidate algorithms, methods, scenarios for initial demonstrations - proceeding on schedule**

J. Ellis

- **Navigation Tracking Strategies and DSN Operations Requirements for Discovery and SMEX Class Missions**
  - **Delayed work due to unavailability of key personnel**

Navigation
FY98 Q1 Accomplishments (cont.)



L. Cangahuala, R. Bishop (UT)

- ✓ **Adaptive Interplanetary Navigation**
  - **Prepared ARTSN prototype for delivery to UT for adaptive filtering demonstration**
    - **Began to augment contract to account for software transfer**
    - **Prepared draft of ARTSN User Guide for UT collaborators**
  - **Reviewed ARTSN role in demonstration with UT colleague**

B. Williams, D. Scheeres (ISU)

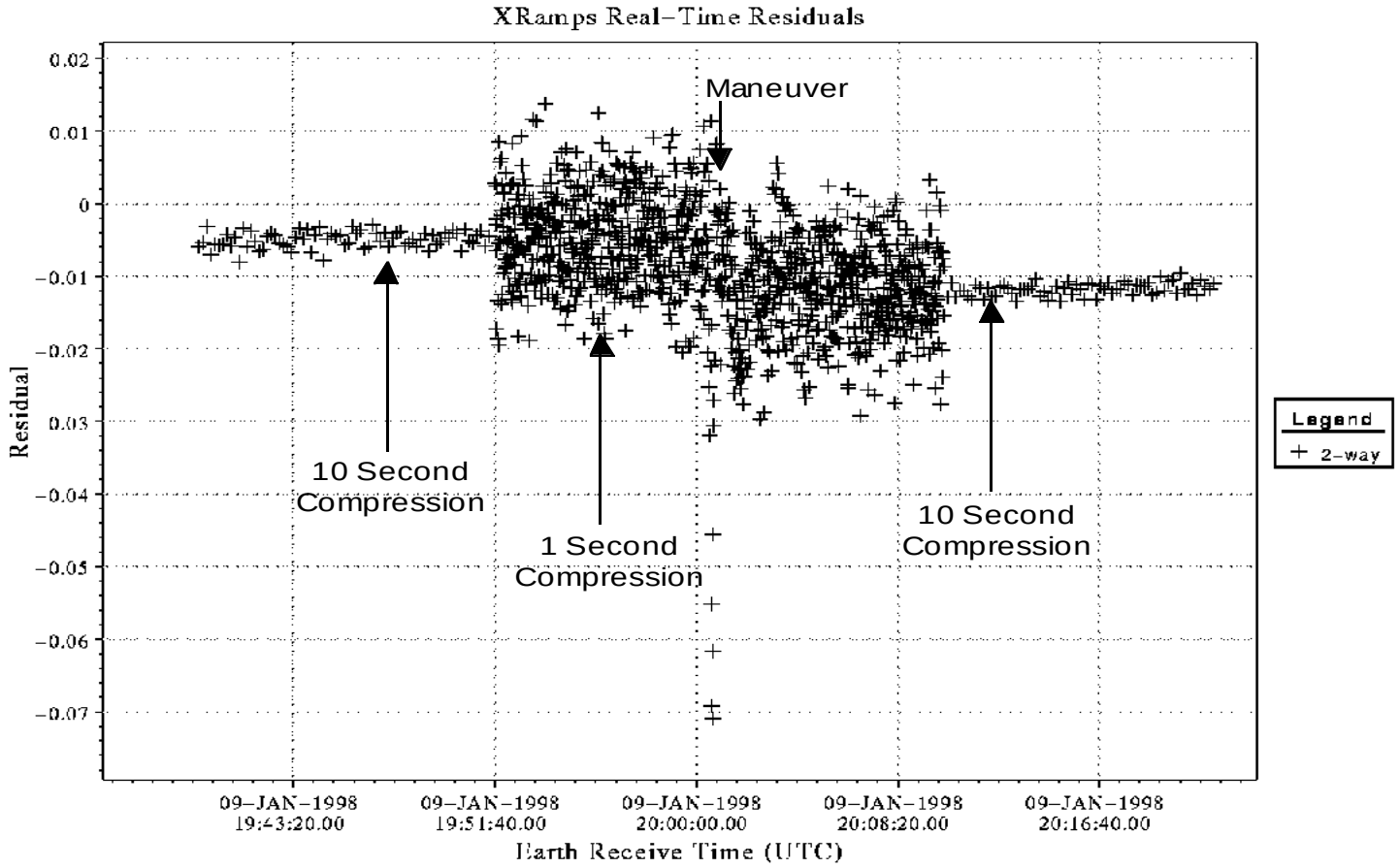
- ✓ **On-Board and Ground-Based Navigation Tradeoffs for Close-Proximity Operations and Landing on Small Bodies**
  - **Began developing software tools to characterize ground-based and on-board navigation capabilities with new graduate students**

M. Lo, D. Scheeres (ISU)

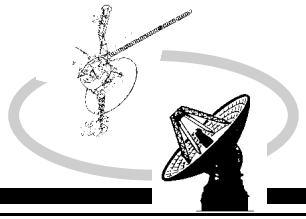
- ✓ **Navigation in Unstable Orbits and on Unstable Manifolds**
  - **Determined strategies for optimizing tracking requirements for halo orbits**
  - **Submitted results to AIAA/AAS Astrodynamics Specialist Conference**

Navigation
FY98 Q1 Accomplishments (cont.)

- **RAMPS Demonstration - Real Time Display of Validated 2-Way Doppler Residuals With User-Controlled Compression Rates During NEAR Maneuver (9 Jan 98).**

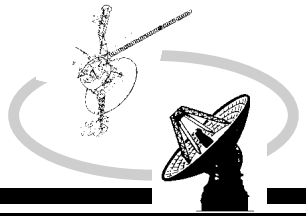


Navigation
FY98 Q2 Planned Accomplishments



- **Deliver RAMPS prototype for testing**
- **Complete plan for 'Next Generation' navigation software suite**
- **Select candidate scenarios for autonomous maneuver design demonstration**
- **Begin tracking strategy and operations requirements study**
- **Deliver ARTSN prototype and User Guide to UT for adaptive filtering demonstration**
- **Complete characterization of ground-based issues for small body navigation**
- **Complete orbit uncertainty study for unstable orbits**

Navigation
Schedule



Task	FY98 Expanded
	Q1 Q2 Q3 Q4
"Stepping Stone" Approach to the Next Generation Navigation Software System	
RAMPS (new sub-task)	Initial Design; NEAR, MGS Demos; Delivery
New System Design	System Design
Automated Maneuver Optimization	Select Scenarios; Determine Algorithms, Methods
Navigation Tracking Strategies and DSN Operations Requirements for Discovery and SMEX Class Missions	Initial Tracking Strategy Recommendations
Adaptive Interplanetary Navigation	Deliver ARTSN Prototype; Adaptive Filtering Demo
On-Board and Ground-Based Navigation Tradeoffs for Close-Proximity Operations and Landing on Small Bodies	Ground-Based Issues; Analysis Tool
Navigation in Unstable Orbits and on Unstable Manifolds	Orbit Uncertainty Study; TCM Study
Resources by FY ($K):	540